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Economic Analysis of Farming Systems: Capturing the Systemic Aspects

C.A. Rama Rao*, B.M.K. Raju, Josily Samuel, Ravi Dupdal, P. Sudhakar Reddy, D. Yella Reddy, E. Ravindranath, M. Rajeshwar and Ch. Srinivasa Rao

ICAR-Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad-500 059, Telangana

Abstract

The paper has attempted to expand the evaluation criteria of farming systems beyond profitability. The proposed methodology has been exemplified with a study conducted in a village in Pudur mandal of Rangareddy district of Telangana. The data on the inputs and outputs of a system and their utilization were collected through a well-structured pre-tested schedule from 20 sample farmers, in such a way that it captured the material flows into and out of the components of the given farming system. The market dependency ratio has been computed for different farming systems. A varying structure of household income has been noticed for different farming systems. The highest household income has been observed in case of the system containing rainfed and irrigated crops along with livestock rearing. The input-output ratio has been found highest in the farming system containing rainfed and irrigated cropping. The market dependency ratio for inputs has been found to be lowest (46%) for the system containing rainfed and irrigated cropping along with livestock and the highest for the system with rainfed and irrigated cropping only. The relationship between market dependency ratio and farm size, family size and number of components in a farming system has also been analysed. The farming systems that can minimize the need for external inputs have a key role in sustaining agricultural systems in the rainfed agriculture. Such an expanded analysis of farming systems will be useful in planning for technology generation and transfer in the Indian agriculture.

Key words: Farming system, market dependency ratio, MDR, input-output ratio, Telangana

JEL Classification: Q12

Introduction

Indian agriculture is dominated by small holdings and smallholders cultivate 42 per cent of the land and constitute 83 per cent of the total landholdings (Chand *et al*., 2011). However, most of these farms produce more than one commodity and are operated largely by the farm families. The choice of the commodities produced is determined by a number of factors related to household objectives, natural resource endowments, farm physical assets and markets. All these together is referred to as a farming system. Thus, a farming system refers to a combination of enterprises involving raising of crops and livestock together. The farming system approach is seen as a potential way of raising and stabilizing productivity and profitability levels in the rainfed agriculture (Venkateswarlu *et al*., 2012; Gopinath *et al*.; 2014; Osten *et al*., 1989). Different components of farming systems are organically linked in a way that there would be material flows from one component to another component. The output of one component of the farming system serves as an input to the other component. Thus, farming systems integrate

* Author for correspondence
Email: carrao@crida.in

different enterprises. In a farming system, the farm family is also intimately linked to the components. Farming systems are holistic in their scope and are based on ecological, economic and demographic considerations.

Farming Systems Research – An Overview

Some roots of the farming systems research are evident in as early as 1930s in the American State Rural and Extension Programs of the 1930s. In the developed countries, much of the pre-World War II work focused on-farm management problem-solving with a systems and farm-household perspective. During the mid-1960s, some geographers and economists found the systems concept to be a useful way to describe the variations in agriculture across different countries in the world (Kirway *et al*., 2003). Later, the observed slower rates of adoption of technologies developed by agricultural research systems have been the important reason for the interest in understanding how farming systems work. Both international and national agricultural research organizations recognized the importance of building farming systems perspective into agricultural research and extension. It was observed that the nature of existing farming systems would influence the adoption of technologies (Feder *et al*., 1985) which was why the adoption rates were slower or lower than expected. Thus, approaches based on farming systems have been seen as important in generation and transfer of agricultural technologies.

In India, the farming systems are characterized by small farm size, production of a number of crop and livestock commodities and aim at more stable incomes besides profit maximization. The farming systems can be described and understood by their structure and functioning. The structure in its wider sense includes among others, the land-use pattern, production relations, land tenures, size of holdings and their distribution, irrigation facilities, marketing including transport and storage, credit institutions and financial markets and agricultural research, education and extension. Thus, the "farming system" is the result of a complex interaction among a number of interdependent components. Minimizing the dependence on external markets is also an important factor that determines the structure of a farming system and a farming system analysis should consider these aspects. Hence, the data requirements for analysing farming systems are relatively heavy compared to what is done in crop or component analysis. However, many farming system analyses are limited to putting together the component level analyses rather than analysing the functional linkages in the system (Shaner *et al.*, 1981; Dixon *et al*., 2001).

The agricultural research in India was directed in the beginning to cataloguing of farmers' cropping practices. Later, research attempted to study the farming systems related to drought-prone areas based on the traditional and subsistence agriculture. And these led to studying of different crop-based cropping systems, viz, cereal-based, etc. and the profitability of these systems were analysed (Kanwar, 1992). Some studies found integrated farming system (IFS) improved the livelihoods of farmers and they also studied the inter relationships between the different enterprises in farm. These studies summed up the net returns of individual components in the system to arrive at the overall profitability of the system (Singh *et al*., 2011; Balusamy *et al*., 2003; Hari Om *et al*., 2008; Radha *et al*., 2000; Gill, 2004; Singh, 2004; Singh *et al*., 2007; Ramrao *et al*., 2005). Some studies have also revealed higher employment generation through taking up different enterprises.

A farming system is essentially cyclic (organic resources – livestock – land – crops) and the components in the system are inter-related and the decision on one affects the other. The resource flows models in different farming systems were also studied (Rana and Chopra, 2013). Most of the research on farming systems provided inadequate attention to the interrelationships and contribution of one enterprise to other components of the system. The farming system conceptually is a set of elements or components that are interrelated which interact among themselves. The quantification and economics of the relationship have not been systematically studied with farmers' data. Therefore, such analyses often fail to provide the contribution of each component to the total system productivity. Keeping the above points in view, this paper has attempted to expand the criteria of evaluation of farming systems beyond profitability. Specifically, the paper has captured the linkages within the system in the form of proportion of inputs generated and outputs utilized within the system. The methodology has been illustrated using the data obtained from the Rangareddy district in Telangana.

Data and Methodology

The study was conducted in a village in Pudur mandal of Rangareddy district of Telangana. The agriculture in this district is largely rainfed with only 22 per cent of cropped area having access to irrigation. Data were collected from a random sample of 20 farmers[1]. The average annual rainfall in the district is about 730 mm. The district is prone to incidence of drought. The district has net cropped area of 2.29 lakh ha. The major crops grown are sorghum, rice, pigeonpea, cotton and castor. The cropping intensity in the district is about 111 per cent (Kareemulla *et al*., 2008). About 45 per cent of the total farmers have holdings less than one hectare in size (Agricultural Census, 2011, http://agricoop.nic.in/).

The data on the inputs and outputs of a system and their utilization were collected through a well-structured pre-tested schedule such that it captured the material flows in to and out of the components of the given farming system. Generally, annual gross margin and net household income were used as tools for analyzing farming systems. Though these measures summarize the overall performance of the system, they do not reveal the linkages between the components. The gross margin was calculated as the difference between the value of all outputs generated from the system and the value of all variable costs. The variable costs included inputs (i) generated within the farm and family, (ii) sourced within the village community (e.g., fodder from village common pool resources), and (iii) purchased from outside and were valued at the market prices. The first two categories of inputs were categorized as internally-generated inputs as they did not involve any cash expenditure[2]. Similarly, outputs were divided into internally utilized and externally sold. For example, fodder is internally generated input to the livestock owned by the farmer. The fodder is an output that is internally utilized.

Using the data so generated, market dependency ratio (MDR) was computed for the inputs as a ratio of value of purchased inputs to the value of total inputs used in the system. A higher ratio indicates higher dependency on market and to that extent a farmer is exposed to the uncertainties of market. A lower ratio, on the other hand, indicates not only a lower dependency on the markets but also higher sustainability as most inputs are generated within the system. The difference between the market value of the input that can be generated within the system and the cost of production of the same input is also a kind of hidden profit, especially when the markets for such outputs (inputs) are not well developed. A similar measure was computed for output also. A higher measure in this case indicates that a lower proportion of outputs is utilized within the system and thus has implications to the cash flow. These measures were computed for the farming systems identified within the sample farmers.

Results and Discussion

Farming Systems in Study Area

Using the data collected from the farmers, four different farming systems were identified in the Rangareddy district. They included rainfed crop systems (RF), rainfed crop + livestock (RF+LS), rainfed crop + irrigated crop (RF+I), rainfed crop + irrigated crop + livestock (RF+I+LS) systems. Table 1 gives the characteristics of the farming systems. The average farm size of RF and RF+LS systems was less than 3 acres, whereas the farm sizes of other two systems with irrigation were 3.5 acres and 5 acres, respectively. The average family size varied between 4.33 and 6.75 in different farming systems. The major crops grown under all the farming systems were cotton, maize, pigeonpea and rice. Livestock component included cows, buffaloes and bullocks.

Profitability of Farming Systems

Profitability is an important and overarching objective of any farm enterprise. Table 2 gives the

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[1] The data requirements for a farming systems analysis are very heavy. The purpose of this paper was to illustrate a methodology for a better farming systems analysis. Hence, the sample size was limited.

[2] Though community generated inputs are external to farm and family, the decisions regarding livestock enterprises are considerably influenced by the availability of and access to such inputs with little cash expenditure involved. In this study, the extent and proportion of such resources/ inputs were negligible and hence we included them as internally generated resources. It will be ideal to consider them as a separate category when their contribution is significant, as, for example, can be observed in the case of small ruminants that sustain predominantly on open grazing of common pool resources.

Table 1. Key characteristics of farming systems in Rangareddy district, 2012-13

Particulars	Rainfed crop	Rainfed crop + Livestock	Rainfed crop + Irrigated crop	Rainfed crop + Irrigated crop + Livestock
Farm size (acres)	2.42	2.6	3.5	5
Crops	Maize + pigeonpea (0.77) Cotton + pigeonpea (0.40) Ajwain (0.40)	Pigeonpea (0.40) Cotton (0.8) Rice (0.30)	Cotton (0.70) Maize + pigeonpea (0.60) Pigeonpea (0.60)	Cotton (0.58) Chrysanthemum (0.27) Fodder (0.20) Sorghum (0.40) Maize + pigeonpea (0.68) Rice (0.38) Pigeonpea (0.76) Tomato (0.37) Turmeric (0.40)
Livestock	0	Buffalo (0.2) Cow (0.4) Bullock (1.6)	0	Buffalo (3.13) Cow (0.13) Bullock (0.75)
Family size (adult equivalents)	4.33	6.6	5	6.75
Number of households	6	5	1	8

Note: The figures within the parentheses denote area in acres/number of livestock per farm.

Table 2. Income composition of farmers practising different farming systems, Rangareddy district, 2012-13

(₹ /household)

Particulars	Rainfed crop	Rainfed crop + Livestock	Rainfed crop + Irrigated crop	Rainfed crop + Irrigated crop + Livestock
Crop	11374 (52)	12668 (41)	32337 (81)	26709 (57)
Livestock	0	5076 (16)	0	12638 (27)
Others (wages, etc.)	10417 (48)	13125 (43)	7500 (19)	7422 (16)
Total	21791 (100)	30869 (100)	39837 (100)	46709 (100)

Note: The figures within the parentheses indicate per cent to total income from the system.

levels and composition of income of households practising different farming systems. The household income from the rainfed farming system was ₹ 21791 of which 52 per cent was contributed by crop production and 48 per cent by wage earning. The households having livestock in addition to rainfed farming derived about 41 per cent of their income (₹ 12668) from crop production and 16 per cent from livestock. The contribution of wage earning decreased to 43 per cent. The dependence on wage earning was less in the case of farming systems containing irrigated crop production as the contribution of crop production increased considerably. The highest household income was observed in case of the system containing rainfed and irrigated crops along with livestock rearing. The (RF + I) system had the highest per acre crop income (₹ 9239/ac) and RF + LS system had 3.5 per cent more per acre crop income than RF system. The crop

Table 3. Labour productivity in different farming systems, Rangareddy district, 2012-13

(₹ /household)

Farming systems	Labour productivity (₹/man day)	Number of family labour days (man days/household)	Returns to family labour	Returns to per unit family labour
Rainfed crop	506	40	17817	445
Rainfed crop + livestock	421	144	39244	273
Rainfed crop + irrigated crop	576	73	44783	614
Rainfed crop + irrigated crop + livestock	464	344	93045	271

production contributed about 57 per cent to the total household income in case of the farming systems containing all the three components — rainfed crops, irrigated crops and livestock. The contribution of livestock was about 27 per cent in this system. The contribution of farm income in the total household income was found to be highest (84%) in the case of system containing rainfed and irrigated cropping along with livestock. The varying structure of household income in different farming systems is determined partly by how different components in a farming system are linked organically and the material flow from one component to the other helps in increasing the income of farmers.

Labour-use and Productivity in Different Farming Systems

Utilization of family labour and maximization of labour productivity are also the important determinants of composition of a farming system. Table 3 presents the labour productivity for different farming systems. It is observed that the productivity for unit of labour (for total labour as well as for family labour) was low for the farming system with livestock as a component, indicating the labour-intensive nature of livestock enterprise. On the other hand, the family labour was better utilized in the farming systems containing livestock component. The role of livestock in smoothening consumption during bad weather years, in meeting consumption needs of the family and relatively low opportunity cost of family labour are probably some of the reasons why farmers keep livestock despite low labour productivity. However, improvement of livestock productivity by better breed management, feed, fodder and health management will be helpful in improving the labour productivity (Birthal *et al*., 2006).

Market Dependency Ratio in Different Farming Systems

The material flows were valued at the market price and market dependency ratio (MDR) was calculated for different farming systems. The results revealed that input- output ratio was highest in the (RF+I) farming system (1.62), indicating that the farmers with this system were able to get ₹ 1.62 for every one rupee spent (Table 4). The lowest input-output ratio was observed in the case of the rainfed crop + irrigated crop + livestock farming system. In fact, the input-output ratio was smaller when livestock component was added. This is perhaps because of the labour-intensive nature of the enterprise. This, when considered with the finding that lower labour productivity was associated with livestock rearing, explains the reported reluctance among farmers to diversify farming towards more livestock-intensive systems, especially at a subsistence scale (Tulachan and Neupane, 1999; Misra *et al*., 2006).

The market dependency ratio can be considered as an important indicator that reflects the dependency on markets for obtaining stable income. A lower value of MDR for inputs is better as it would mean that farmers have incurred less expenditure on inputs. On the other hand, a lower MDR for outputs indicates that farmers are not subjected to price volatility. It would also mean that the ability of farmers to take advantage of the rising and expanding markets is limited. The MDR for inputs was found to be lowest (46%) for the system containing rainfed and irrigated cropping along with livestock and the highest (74%) for the system with rainfed and irrigated cropping only. On the other hand, the MDR for outputs was found to be higher in the case of rainfed cropping based systems only. The absence of foodgrain crops in these two systems was

Table 4. Performance indicators of different farming systems, Rangareddy district, 2012-13

Particulars	Rainfed crop	Rainfed crop + Livestock	Rainfed crop + Irrigated crop	Rainfed crop + Irrigated crop + Livestock
Value of output (₹ /household)	36483	71006	84700	183235
Value of input (₹ /household)	25109	53262	52363	143888
Input-output ratio	1.57	1.34	1.62	1.3
Market dependency ratio for output (%)	83	82	66	65
Market dependency ratio for inputs (%)	74	48	76	46

the reason behind the higher MDR value for outputs. The two farming systems with irrigated cropping as a component were found to have a relatively lower MDR for outputs because of the presence of foodgrain crops (rice) and dairy enterprise.

The MDR is a function of the nature of enterprise mix in a farming system which in turn is determined by, among other things, family size, which on one hand influences the household food needs and on the other determines the labour availability. The farm size is another important factor that determines the enterprise mix in a farming system. Therefore, the relationship of MDR with these factors was examined by considering the data for all the 20 households in the sample.

It was hypothesized that MDR for inputs would be negatively associated with the number of components in a system as such diversity would enable material input flows across different enterprises. It is observed from Figure 1 (a) that the MDR for inputs tended to decrease as the number of components increased. On the other hand, such a negative relationship between the number of components and MDR was not so evident in the case of outputs [(Figure 1(b)]. The MDR for inputs was found to increase as the family-size increased, while the MDR for outputs showed a negative relationship with family-size (Figure 2). The larger farms are generally associated with more area under a given crop (Rama Rao *et al*., 2011), more fragments per farm[3] (NSSO, 2006), larger input requirements and less participation of family labour and hence the potential for internal generation and use of inputs/ outputs is limited which is reflected in the positive relationship between MDR and farm size (Figure 3).

The MDR at the system level is a function of the components of a system. For example, the presence of livestock component can reduce the dependence on external fertilizers to some extent and similarly the by-

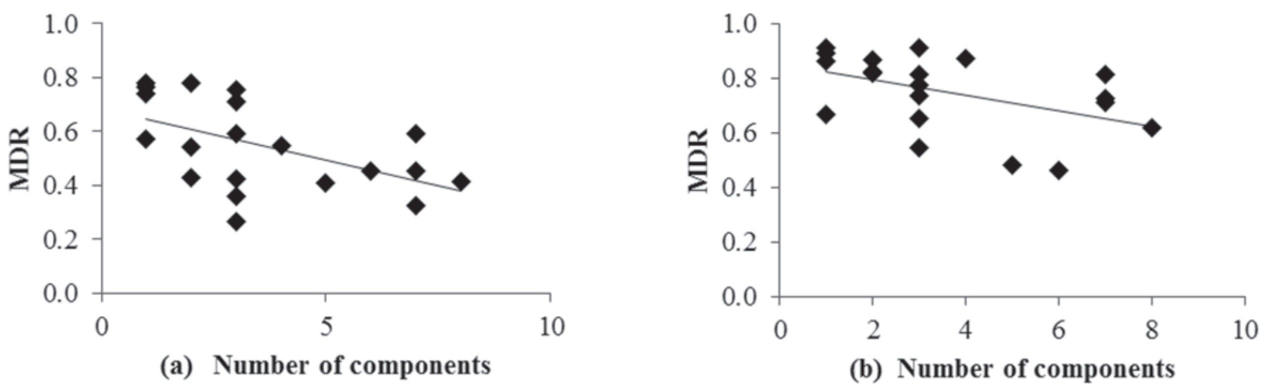

Figure 1. Relationship between market dependency ratio for (a) inputs (b) outputs and the number of components

[3] The number of fragments or parcels per holding in case of (undivided) Andhra Pradesh increased from 2.4 in case of holdings between 0.5 and 1.0 ha in size to 4.2 in case of holdings between 5.0 and 7.5 ha in size (NSSO, 2006)

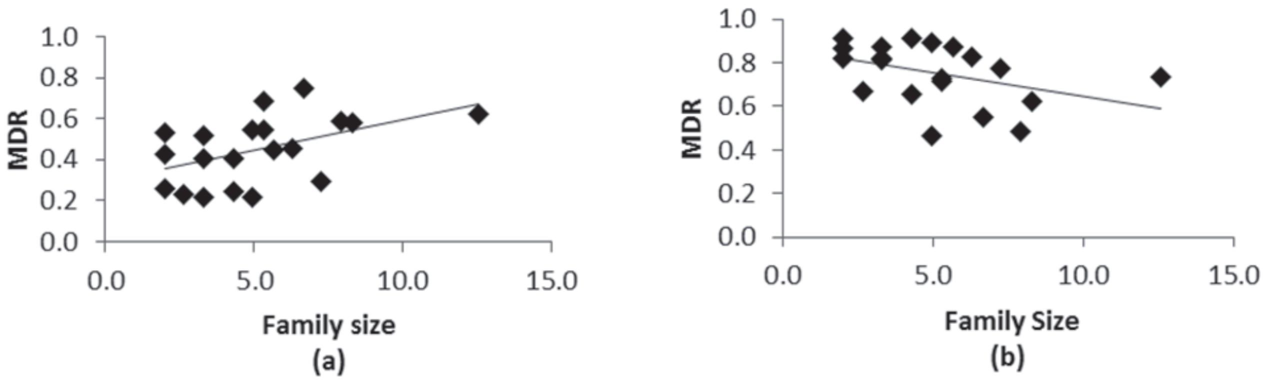

Figure 2. Relationship between market dependency ratio for (a) inputs (b) outputs and family size

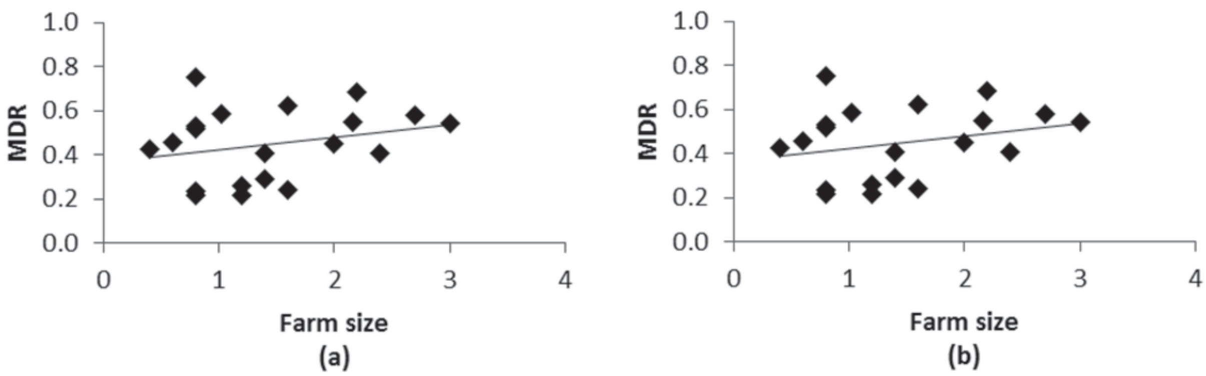

Figure 3. Relationship between market dependency ratio for (a) inputs (b) outputs and farm size

Table 5. Market dependency ratio of outputs and inputs of different farming systems, Rangareddy district, 2012-13

(in per cent)

Farming system	Crops	Inputs	Outputs
Rainfed crop	Cotton + Pigeonpea	76	79
	Maize + Pigeonpea	73	89
	Ajwain	59	94
Rainfed crop + livestock	Cotton	63	100
	Maize+Pigeonpea	41	80
	Pigeonpea	53	95
Rainfed crop + irrigated crop	Pigeonpea	53	88
	Cotton	83	100
	Rice	70	23
Rainfed crop + irrigated crop + livestock	Cotton	71	100
	Chrysanthemum	54	100
	Fodder	32	0
	Sorghum	39	24
	Maize+Pigeonpea	54	67
	Rice	62	0
	Pigeonpea	62	69
	Tomato	49	98
	Turmeric	86	100

products of crops such as rice and sorghum, will meet the fodder requirements of livestock to some extent. How the MDR for the same crop varies in different systems reflects such interactions between the components in a system (Table 5). For example, the MDR for inputs in the case of maize + pigeonpea system, present in three out of the four farming systems, varied between 0.41 and 0.73. The MDR for inputs was found to be least in the case of system containing rainfed cropping and livestock. The average farm size is lower for this farming system and the contribution of family labour is more prominent in smaller farms. This, together with contribution of livestock in the form of manure, is reflected in the lower MDR (Table 5).

In the case of outputs, the MDR was found to be lower in a system containing rainfed cropping and livestock (0.80) compared to the one without livestock (0.89) as some part of the output of maize and pigeonpea was used as fodder for livestock and foodgrain for family consumption. The MDR for cotton was 1.00 in all the systems as it was produced wholly for the market. The lower MDR of outputs was observed for fodder, sorghum and rice as some part of their outputs are used within the system.

Conclusions

The farming systems are helpful in addressing the multiple needs of a farm family as well as in stabilizing incomes. Thus, they have a considerable role in the rainfed agriculture characterized by harsh and diverse production environments. This study has evaluated the prominent farming systems in a district where agriculture is largely rainfed by examining profitability, labour productivity and market dependency ratios.

It has been observed that farming systems containing livestock tended to reduce the dependency on market for inputs as a considerable amount of inputs was generated within the system. The observed lower productivity of labour is a potential impediment to adoption of mixed crop-livestock farming systems or to expanding the size of livestock enterprise in the existing systems. The farming systems were also found to vary in terms of dependence on markets for inputs and outputs. The farming systems that can minimize the need for external inputs have a key role in sustaining the agricultural systems in rainfed agriculture. An analysis of farming systems with such a broadened criteria will be helpful in planning technology generation and transfer. Further research on farming systems evaluation is needed considering other aspects such as temporal variability in demand for and availability of inputs, especially for labour.

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